REMARKS

In this preliminary amendment, I am amending my claims as well as prepared an explanation on the similarity between the claims of patent 6,546,796 and my patent application 10,736,116.

New claims Support in the Specifications of patent application # 10,736,116.

New claim 16 Remarks :

In my Figure 6, element # 61 is a substrate having a longitudinal axis when it is inserted inside container 10 in my Figure 1.

I have two heater designs of my probe. One, shown in Figure 6, the separate heater , element # 62 is attached to substrate 61. Second, in Figure 9 where the heater , element 60 is also used as the common wire for a set of thermocouples connected in parallel. In such parallel configuration, there is a single common cold junction.

A plurality of thermocouples is shown in Figure 6 , with Copper traces , elements 71 to 80 , and a common Constantan trace or ribbon or wire, element 60 in Figure 6. These thermocouples just measure the temperature along a heater, before and after, power is applied to the heater. Therefore, the temperature of points along the heater, can be measured at each point with parallel thermocouple configuration or the temperature of those points can be added up with a serial configuration of the thermocouples. Similarly in Figure 9, elements 71 to 80 are the Copper traces and element 60 is the Constantan leg of the thermocouples. In Figure 9, the Constantan, and element 60 is also used as the heater. Since this heater has a long response time (i.e. 20 seconds),

if we take quick sampling of the thermocouples, during this quick sampling of the thermocouples, the heat will not leak from the heater. Therefore, the Constantan under those circumstances can be used as a heater as well as a common wire to the thermocouples.

The coating on the heater is shown as a thin layer, element # 64 in Figure 6.

Power to the heater is applied by power source 90 in Figure 6 or element 52 in Figure 2.

In Figure 1, element # 10 shows the liquid container, element # 11 shows the liquid and element # 20 shows the probe.

Element # 31 in figure 1 shows the display of the sensor measurement and element # 50 in figure 2 shows the data acquisition and signal conditioning circuitry.

The power supply is shown as element # 90 in Figure 6 and the data acquisition circuit is shown as element 81 in figure 6. Those elements could be mounted on the substrate.

New claim 17 Remarks :

In Figure 6, the hot junction of each thermocouple generates an opposite voltage (emf) to the voltage (emf) from the common cold junction.

New claim 18 Remarks :

In Figure 3A, line # 112 (which has a value close to line # 55) is used to determine the temperature rise of the un-submerged section of the heater, after the heat is applied to the heater. This section of the heater is not closed to the liquid level. Due to the use of high pressure to

compress the air above the liquid in a hermetically sealed container, the density of the air will be a function of the pressure. When the density of the air gets bigger, the air will suck more heat from the heater. Thus the height of line 112 or equivalently, line # 55 will be lowered. The amount of lowering or increasing of either of those lines, will measure the pressure of the air. Line # 112 is measured by the thermocouples of figure 6. Instead of having a single thermocouple configuration and use the thermocouples that are far away from the liquid level, as in Figure 6, it is possible to make the same measurement with two thermocouple configurations and two separate signal conditioning circuits.

New claim 19 Remarks :

The power from element 90 to the heater, not the thermocouples, is applied to the heater, element 62 in Figure 6 or Element 60 in Figure 9. The temperature that is read by the thermocouples for points along the heater, is the steady-state temperature of the heater after the power is applied. The power needed for the temperature of the heater, to reach steady-state value can be applied in different ways. The value of the temperatures of point along the heater is what is used to determine the continuous liquid level

New claim 20 Remarks :

In Figure 1 , element 55 is the data acquisition. Part of it is the signal conditioning circuit.

In Figure 6, the voltage (signal) from the difference between the individual hot and cold thermocouple junction is supplied to data acquisition , element # 81, in Figure 6.

New claim 21 Remarks :

Probe , element # 20 in Figure 1, and the probe components in figure 6 show that the thermocouple junctions are positioned along a line extending generally parallel to the surface of the liquid, element # 11 in Figure 1.

New claim 22 Remarks :

Figure 3A shows the three sections, (i.e. 111, 110 and 112) that will be used to determine different liquid properties.

New claim 23 Remarks :

Figure 3A shows the temperature profile (continuous) constructed for the entire length of the heater by reading the temperature of discrete point along the heater. The temperatures of those discrete points along the heater are measured with thermocouples. The temperature of each thermocouple is read before and after power is applied. The temperature of each thermocouple before power is applied is used as a reference or zeroing position for each thermocouple. The continuous temperature profile of Figure 3A is constructed from the discrete temperature rise of each point along the heater relative to the zero position of its own thermocouple.

New claim 24 Remarks :

In Figure 9, element # 60 is the common heater and common wire.

New claim 25 Remarks :

For stratified liquid, each liquid will have its own continuous temperature profile with its own three sections [i.e. section 110,111 and 112].

New claim 26 Remarks :

The discrete liquid level can be calculated by using either a known reference point in liquid or air. Either reference point is located along the heater. Instead of using a separate reference point, either the bottom or top point on the heater and its corresponding thermocouple reading, before and after power is applied, can be used.

New claim 27 Remarks :

A continuous or pulsed power applied to the heater is shown in Figure 1, as a power source, element 52, and a switch , element 53. Another form of power circuit might include inductor and capacitors to apply high power over a short time interval with an average low power over a long time interval.

As a result of applying power, the temperature along the heater rises. The temperature of discrete points along the heater is measured with thermocouples. The temperature from the thermocouples, is sent through multi-plexers, elements 93 and 94 in Figure 10 , to an amplifier, element 96 in figure 10. The signal from the amplifier is sent to the Analog to Digital converter, element 98 in figure 10 and from the Analog to Digital Converter, the signal goes to a microprocessor.. element 22 in Figure 10. The microprocessor, as shown

in figure 10., also controls the operations of the multi-plexers as well as the power circuit, element 95.

New claim 28 Remarks :

The errors of bias and slow drift in the electronics are common to all the thermocouple readings that are sent to the microprocessor. By using a temperature profile of Figure 3A to the next level, such that for example, line 111 is used a reference line, then those common non-random errors will be taken out. For the random errors, statistical analysis methods can be used to process the data to get the best estimate for the reading of each thermocouple. Additionally a filtered reading of each thermocouple by a fixed gain filter or a Kalman filter (i.e. variable gains) in combination with averaging can also be used as part of the digital software.

New claim 29 Remarks :

In Figure 10, element 97 is an absolute temperature sensor that can be located at the cold junction or other points in the sensor. Suppose that it is located at the cold junction, point A in the enclosed Figure 6. The temperature (or voltage, (emf) of each hot junction relative to the cold junction will give the absolute temperature of each hot thermocouple junction. The microprocessor will have stored in it the voltage versus temperature curve for any thermocouple that is used. From this temperature curve and the absolute

temperature reading of element 97 in Figure 10, the absolute temperature at the location of each hot thermocouple junction can be calculated.

New claim 30 Remarks :

For a given amount of power, the temperature profile of Figure 3A will look different for different liquids. For example, for engine oil with low viscosity, like 30-weight oil, line 111 in Figure 3A will have lower height than more viscous oil like 50-weight engine oil. Moreover, for lower viscosity oil, the curved section of the profile in Figure 3A, i.e. element 110, will have different steepness or shallowness for those two liquids at the same temperature and power for both liquids.

Comparison of Similarity in Patents

Before I show why some of Mr. Zimmermann claims are explained in my patent application, I need to explain a few basic points:

First, Figure 3 in patent # 6,546,796 is similar to figure 3A in my patent application # 10,736,116.

Explanation: First, Mr. Zimmermann took the sections 110, 111 and 112 of my Figure3A and made the following cosmetic changes to my Figure 3A to get Figure 3 in patent # 6,546,796. First, Instead of Thermocouple Number Axis in Figure 3A , he called it Oil

Level (cm) in his Figure 3. Second, instead of converting EMF (Voltage) from Thermocouple to temperature to plot the Temperature Axis in Figure 3A, he just called it Probe Output (V). Third, instead of using three section [i.e. 110,111 and 112] to get a temperature profile in my figure 3A, to determine continuous liquid level in the presence of non-uniform errors, Mr. Zimmerann took Figure 5 [which is section 110 in my Figure 3A] and added it one time for each thermocouple on the probe. As a result, Figure 3 of patent # 6,546,796 is really just adding Figure 5 [or equivalently Table 2 but with thermocouple temperature replaced by thermocouple voltage] in my patent application. For example, if there are 5 thermocouples on Mr. Zimmerman probe that are placed 12.7 mm apart, then all 5 thermocouples are heated in air, adding the thermocouple voltage will give 5X 7.7213 = 38.506 degrees or equivalently if one takes 40 microvolt for each degree C for type T thermocouples, the added voltage will be 1.54 mili-volt.

The invention is about inventing the temperature [voltage] profile and how to make it consistently change as the liquid level rises and fall in the presence of localized error sources.

Second, **the discrete heaters of Figure 2 in patent # 6,546,796 give similar temperature (voltage) profile like Figure 3 in this patent, similar to temperature profile of a single continuous heater**. Mr. Zimmermann uses apparatus in his Figure 6 that uses a single continuous heater and in Figure 2 he uses discrete heaters. Then in his specification on Column 8 line 34 he writes " Alternatively, discrete heating resistors may be used in place of heater wire **108** ". In other words, Figure 3 of Mr. Zimmermann

will be used as the method to determine continuous liquid level whether he uses a single continuous heater as in Figure 6 or discrete heaters as he uses Figure 2.

In my patent application # 10, 736,116, I am using a single continuous heater.

Third, Mr. Zimmerman measures the temperature along a heater using a type T thermocouples that are serially connected while I measure the temperature rise along a heater with type T thermocouples that are connected in a parallel configuration. It should be noted that what is giving the information about the liquid level is the temperature changes along a heater and not the temperature sensors themselves. In serially connected thermocouples, each thermocouple has its own hot and cold junction and the temperature difference between each hot junction is measured relative to its own cold junction and then those differences are summed up. In a parallel thermocouple configuration, there is a single common cold junction (point A in Figure 6) to all of the hot junctions.

At this point, I will list the claims in patent # 6,546,796 that are based on the specification in my patent application # 10, 736,116.

1) Claim 17 in patent # 6,546,796.

" 17. A liquid level sensor comprising :

a substrate having a longitudinal axis ;

a first plurality of thermocouples provided on one side of said substrate in longitudinally spaced relationship ;

a second plurality of thermocouples provided on said one side of said substrate in longitudinally spaced relationship to each other, respective one of said second plurality of thermocouples being positioned in laterally spaced relationship to respective ones of said first plurality of thermocouples ;

said first and second thermocouples being interconnected in alternating series relationship ;

a heat source for increasing the temperature of each of said plurality of thermocouples; and

heat sink provided on said substrate in close proximity to said second plurality of thermocouples;

said sensor being adapted to be positioned within a vessel containing a volume of liquid with said sensor partially immersed in said liquid such that said first and second thermocouples cooperate to generate a signal indicative of the level of said liquid within said vessel. "

In this claim, Mr. Zimmermann uses an apparatus that consists of a substrate, type-T thermocouples [with hot and cold junctions] to measure temperature along a heater, power source, heat sink for the cold junctions only and a container. Note that if instead of type-T thermocouples another type of thermocouples were used, then this sensor will not work accurately. More specifically, if the thermocouples used have a characteristic of voltage (EMF) versus temperature which is different in different operating temperature, then this analog design of the sensor will have serious difficulties reading the continuous liquid level accurately. For example, for Type T

thermocouple a difference of one degree C between the hot and cold junction, when the environment temperature is between 0 and 200 degree Fahrnheit,

2) will be around 40 microvolt. If another thermocouple type is used and its EMF for one degree C difference at 0 degree is different than at 100 degree Fahrnheit and still different than one degree difference at 200 degree Fahrnheit, then this error source will deteriorate the analog sensor design performance in patent # 6,546,796.

In my patent application, in figure 6, I use a substrate **61.** A type-T thermocouples **71** to **80** Copper traces plus Constantan element **60** to measure temperature along a continuous heater in my Figure **6**, a power supply **90** , a single cold junction that is used for all of the hot junctions [see point A on the top of the Constantan **60 in the attached figure which add the letter A to Figure 6 in my patent application ,** using this single cold junction is equivalent to using the Copper heat sink (**60 in Figure 2 of Mr. Zimmermann patent**) between all of the cold junctions. In my patent application, if needed, I can store the characteristics of the thermocouples and correct its impact on the accuracy of the thermocouple readings.

Here is the explanation on why using a single common cold junction in my patent application is equivalent to using a Copper heat sink between all of the cold junctions in Mr. Zimmermann patent. If I define as Vh1 as the voltage of the hot junction and Vc1 as the voltage of the cold junction of the first thermocouple and similarly define Vh2 and Vc2 for the second thermocouple, then adding the voltage differential of the two thermocouples will be equal to :

(Vh1-Vc1)+(Vh2-Vc2) .

If the liquid level is half way between thermocouple 1 and thermocouple 2, then Vh1-Vc1 will have a given value A. When the liquid level is exactly half-way between thermocouple 2 and thermocouple 3, then Vh2-Vc2 will need to also be equal to A. This will happen only if Vc1 is equal to Vc2 and Vh2 is equal to what Vh1 was when the liquid level was half-way between thermocouple 1 and 2. By using the Copper heat sink, which is a good thermal conductor, all of the cold junctions will have approximately the same temperature regardless of where the liquid level is. Instead of using this complex structural design to have many cold junctions and then make all of the cold junctions have equal temperature, I used a single common cold junction and took the voltage of each hot thermocouple junction relative to that single cold junction.

3) Claim 18 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 17 wherein each of said first plurality of thermocouples generate a first magnitude signal when positioned at a level above the surface of said liquid and a second magnitude signal when positioned at a level below said surface of said liquid, the sum of said first and second magnitude signals being indicative of the level of said liquid within said vessel. "

Mr. Zimmerman claims that since each hot thermocouple junction give a different reading when it is in liquid or air or the liquid level is in-between hot thermocouple junction, then adding the voltage readings from the thermocouples will determine the

liquid level. What Mr. Zimmerman is using to determine the continuous liquid level is my figure 3A for a special conditions.

Now, I will show how Mr. Zimmerman has used my figure 3A to determine continuous liquid level and not any invention of his.

The thermocouples in Mr. Zimmermann patent, are just reading the temperature (voltage) along the heater. It is the temperature (voltage changes from the thermocouples which measure temperature in voltage) changes along the heater that give the ability to determine the liquid level. My Figure 8 shows how the thermocouples along a heater read the changing temperature along the heater when the liquid level rises or fall. The temperature profile (or equivalently, the voltage profile along the heater) as shown in my Figure 3A will determine the continuous liquid level.

Mr. Zimmerman is establishing the temperature along the heater by heating a wire **108 [see line 3 in column 8 of Mr. Zimmermann patent].** Using cold junctions that are connected by what he calls a heat sink, will make the temperature of all of the cold junctions equal to each other. If prior to applying power, the temperature of all of the hot and cold junctions are the same and after applying power, the temperature of all of the cold junctions remain the same, and then Mr. Zimmerman measures the temperature of each hot thermocouple junction relative to any cold junction, then he will get my plot 3A. Based on that 3A figures , he then add the voltage reading from all of the thermocouples to get his figure 3 which is obtained from Figure 3A for special and not general working environment.

4) Claim 19 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 18 wherein said second plurality of thermocouples generate a signal indicative of the ambient temperature within said vessel. "

In Column 4 line 10 of patent # 6,546,796, Mr. Zimmermann writes :

" Heat sink **60** operate to minimize the effect of any heating of cold thermocouples **52** that may result from heating resistors **58** thereby ensuring that cold thermocouples will provide an accurate compensation factor correlated to the ambient temperature."

In my patent application # 10, 736,116, page 38 , two lines from the bottom I wrote the following :

" The invention described herein can also be used to determine accurately the liquid or gas temperature at the thermal junctions of the probe. Since the probe responds to the temperature differential between any two thermal junctions along the common strip (Constantan strip in Figure 9), a reference accurate temperature sensor may be located at a convenient point (or the strip extended to such a point) and the temperature at any other point along the probe is resolvable. The calculation of the absolute temperature of each thermocouple location will be done with software using the thermocouple voltage differential whose non-random errors have been eliminated and random errors have been minimized using filtering which includes averaging and correlation functions. "

Note that in my Figure 10, element 97 is the single absolute temperature sensor that will be used to determine the ambient temperature at each hot thermocouple junctions even when the temperature of each hot junction is different than the other.

If the ambient temperature of both air and liquid everywhere inside the liquid container are the same , and the cold junction **52** in figure **2** of Mr. Zimmermann patent are not heated , then the temperature of the cold junctions will represent the ambient temperature.

If the ambient temperature is not uniform over the length of the air and the liquid and the cold junctions might be heated, then element **60** in Figure **2** of Mr. Zimmermann patent, which Mr. Zimmermann calls a heat sink, is actually a heat spreader which will try to equalize the temperature of all of the cold junctions. The heat sink or heat spreader is made of Copper which is a very good thermal conductor.

4) Claim 22 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 17 further comprising a thermally conductive electrically insulating coating incapsulating said sensor ".

In my patent application # 10, 736,116, page 21 6 lines from the bottom of the page I wrote :

" and a second thin dielectric film 64 electrically isolating the heater strip 63 from the air or liquid to which the probe is exposed. ". The purpose of the thin film above the heater, (

i.e. between the heater and the mediums of air and liquid) is to be a thermally conductive so that the heater will heat a boundary layer in the liquid that is very close to the heater and the thermocouples reading will be dominated by the temperature of the heater and not the combination of heater and thin dielectric film.

5) Claim 24 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 17 wherein said heat source comprises an elongated resistance heater ".

In Figure **6** of my patent application , element **62** is the heated source which compromises an elongated resistance heater.

6) Claim 25 in patent # 6,546,796.

" A liquid level sensor for use in determining the level of a liquid along the length thereof comprising :

an elongated substrate ;

a first plurality of thermocouples provided on said substrate in longitudinally spaced relationship ;

a second plurality of thermocouples provided on said substrate in longitudinally spaced relationship , respective ones of said second plurality of thermocouples being laterally spaced from respective ones of said first plurality of thermocouples ;

said first and second thermocouples being interconnected in alternating series relationship ;

a plurality of heating elements, respective ones of said plurality of heating elements being positioned in close proximity to respective ones of said plurality of first thermocouples ;

said plurality of first and plurality of second thermocouples cooperating to generate a signal indicative of the level of liquid along the length of said substrate when said substrate is at least partially immersed in said liquid “.

In this claim, Mr. Zimmerman is combining the similar functions of my liquid level sensor design in Figure 6 of my patent application with elements of my method of determining continuous liquid level.

The apparatus that Mr. Zimmermann is describing in this claim is made of discrete heaters that give a temperature profile similar to the single continuous heater and thermocouple (temperature) sensors that measure the temperature along the temperature profile. Then using the temperature (voltage) profile he determines the continuous liquid level. It should be noted that Figure 3 in Mr. Zimmerman patent is used for either the discrete heater or the single continuous heater to determine the continuous liquid level. It also should be noted that without the heat sink, if the cold thermocouple junctions do not have the same temperature, then the sensor will not give accurate liquid level reading.

In my patent application # 10, 736,116, in figure 6 I used a single heater , element 62 , a Type T thermocouples , elements 71 to 80 together with the common Constantan, element 60, in my Figure 6. Instead of one cold junction for each hot thermocouple

junction, I used a single common cold junction for all of the hot junctions. Then I use the temperature profile of my figure 3A to determine the continuous liquid level.

7) claim 28 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 25 wherein said first plurality of thermocouples are arranged in a longitudinally extending row, the length of said row being equal to or greater than the desired range of liquid levels to be measured ".

In my patent application, elements 71 to 80 together with the common Constantan , element 60 (i.e. the hot and cold thermocouple junctions) in Figure 6 are arranged longitudinally and will give the temperature profile of Figure 3A only if they extend to a length that is equal or greater than the desired range of liquid levels to be measured.

8) claim 29 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 25 wherein selected ones of said heating elements is positioned in thermally conductive electrically insulated relationship to each of said first plurality of thermocouples ".

It should be noted that if the heater in Mr. Zimmermann patent, is not electrically insulated from the cold junction, then the analog sensor in patent # 6,546,796 will not work. At the same time, the heat from the heater must not heat the cold junctions. In other words, the heaters need to be electrically insulated from both the hot and cold

thermocouple junctions. Additionally, the heater needs to be separated by a thin thermal conductor from the hot thermocouple junctions while thermally insulated from the cold thermocouple junctions.

In my patent application on page 21, 8 lines from the bottom of the page, I have the following words :" a heater strip 62 also attached to board 61 but electrically isolated from said thermocouples network with a thin dielectric film 63" .

The thin dielectric film 63 is electrically insulating the hot thermocouples junctions from the heater and is thin enough to be a thermally conductive in a way that the hot thermocouple junctions will measure very closely the temperature along the heater. Additionally since the single cold junction is far away from the heater, it will be thermally insulated from the heater.

9) claim 30 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 25 wherein said sensor includes third and fourth serially connected thermocouples operative to generate a signal indicative of a pressure within a vessel. "

What Mr. Zimmermann is saying in this claim is that if the density of the compressible fluid above the liquid changes due to pressure, then the temperature rise of the heater in the compressible fluid will change. The higher the density of the compressible fluid becomes, the lower the temperature rise of the heater section in the

compressible fluid will be. The formula that correlates the pressure to density for compressible fluid is :

$$P = G^* R^* T$$

Where G-is the density of the compressible fluid

R- is a constant

T- is the temperature

If T (environment temperature) is the same but P (pressure) changes then the pressure is directly related to the density of the compressible fluid. When the air becomes more dense, under those conditions only, the temperature rise after power is applied can be used to detect pressure deterioration of the compressible fluid. Furthermore, the design for measuring pressure leakage in this patent will work only if the temperature of the entire compressible fluid is uniform. If the entire compressible fluid above the liquid does not have a uniform temperature, then this method of determining pressure leakage will not be a reliable method to detect pressure leakage.

On page 38 of my application, about 7 lines from the bottom of the page, I wrote the following :

"The invention described herein can also be used to determine the density of incompressible liquid. By measuring the temperature of the liquid and its pressure (with

an appropriate pressure-measuring device such as pressure transducer) at the same location, it is possible to compute, with a suitable microprocessor, the density of the liquid."

For the compressible fluid above the liquid , under special conditions, (i.e. temperature of the compressed fluid above the liquid at higher pressure remains equal to the temperature of the compressed fluid at lower pressure), then by looking at the temperature rise of the hot thermocouple junctions far away from the actual liquid level and averaging them, such a reading can give an indication of the pressure leakage.

10) claim 31 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 25 further comprising a heater sensor positioned in heating relationship to said third thermocouples".

Mr. Zimmerman is using a temperature rise in a third hot thermocouple junction to calculate pressure in the compressible fluid. By measuring the temperature rise of the third hot thermocouple junction after power is applied to a heater located above the third thermocouple hot junction, Mr. Zimmermann claim that he can measure the pressure of the entire compressible fluid volume and not just the pressure at the single point where the third thermocouple hot junction is located. This measurement will be reliable only if prior to application of power to the heater above the third thermocouple junction , the compressed medium temperature is the same as the temperature of the liquid and the temperature in the entire compressed fluid volume is uniform.

A more accurate determination of the pressure leakage in the compressed volume can be achieved by using the information given in my figure 3A. fluid When the temperature inside the compressed fluid is not uniform, if the temperature rise of thermocouples 1 and 2 in Figure 3A relative to line 111 are averaged, this will give a more accurate indicator of the pressure in the compressed fluid. When the temperature of the second thermocouples (i.e. cold junctions in Mr. Zimmermann) are not uniform, then Mr. Zimmermann desifn and method will not read reliably the pressure leakage. In contrast, by looking at the change of curvature of line 110 in figure 3A, together with the temperature rise of thermocouples hot junctions 1 and 2, in combination with a single cold junction, one can tell the pressure leakage a lot more reliably and accurately in the presence of error sources that include non-uniformity of temperature of compressed fluid and unequal environmental temperature in the cold thermocouple junctions.

11) claim 32 in patent # 6,546,796.

" A liquid level sensor for use in providing a signal indicative of the level to which said sensor is submerged in liquid comprising :

an elongated substrate having an upper end and a lower end ;

a first series of thermocouples positioned in spaced relationship along the length of said substrate ;

a second series of thermocouples positioned in spaced relationship along the length of said substrate , each of said second series of thermocouples being laterally spaced from a corresponding one of said first series of thermocouples ;

said first and second series of thermocouples being interconnected in alternating series relationship ;

a first electrical lead extending from adjacent said lower end of said substrate to one of said first series of thermocouples located most closely adjacent said upper end end of said substrate and a second electrical ending from adjacent said lower end of said substrate to one of said second series of thermocouples located most closely adjacent the lower end of said substrate ; and

a heat source comprising a plurality of having elements for heating each of said first series of thermocouples, said heat source having electrical connection located adjacent said lower end of said substrate;

said first and second series of thermocouples cooperating to provide a signal indicative of the level to which said substrate is submersed in said liquid ;

power supply leads connected to said electrical connection on said substrate to supply power to said heat source and signal transmitting leads electrically connected to said first and second electrical leads to transmit said signal to a remote indicator, said power supply leads and said signal transmitting leads extending away from said substrate so as to thereby avoid transferring liquid to a portion of said substrate above the level at which it is submersed."

The apparatus described by Mr. Zimmermann consists of a substrate, hot and cold thermocouple junctions that can measure the temperature rise along a heater, summing the reading of all hot thermocouple junctions, lead wires to the heater and lead wires from the thermocouples.

In my patent application # 10, 736,116, I use a substrate as element 61 in my Figure 6 to attach the thermocouples on it , similar hot and cold thermocouple junctions 71 to 80 together with the common Constantan, element 60, in Figure 6 to measure temperature rise along a heater , element 62 in my Figure 6. From this temperature rise at each thermocouple, I get the temperature profile of my Figure 3A. If I sum the readings of all of the thermocouples in my Figure 3A, I will get figure 3 in Mr. Zimmermann patent. In my Figure 1 element 56 is similar to the leading and return wire to the heater in Mr. Zimmermann patent. Also elements 91 and 92 in my Figure 10 are the similar wires (leads) from the thermocouples.

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12) claim 33 in patent # 6,546,796.

" A liquid level sensor for use in providing a signal indicative of the level to which said sensor is submersed in a liquid comprising ;

an elongated substrate;

a first plurality of thermocouples provided on said substrate in longitudinally spaced relationship ;

a second plurality of thermocouples provided on said substrate in longitudinally spaced relationship to each other, respective ones of said second plurality of thermocouples being positioned in laterally spaced relationship to each other, respective ones of said second plurality of thermocouples being positioned in laterally spaced relationship to respective ones of said first plurality of thermocouples ;

said first and second thermocouples being interconnected in alternating series relationship ;

a heat source for increasing the temperature of each of said first plurality of thermocouples comprising a plurality of discrete heating elements respective ones of said plurality of heating elements being positioned in close proximity to respective ones of said plurality of first thermocouples;

a coating overlying said first and second plurality of thermocouples and said heat source said coating being operative to resist retention of liquid above said level to which said sensor is submersed in said liquid;

said first and second plurality of thermocouples cooperating to provide an accurate signal indicative of the level in which said sensor is submersed in said liquid ."

The apparatus in this claim consists of a substrate to mount the hot and cold thermocouples, hot and cold thermocouple junctions to measure temperature rise along a few points along a heater, heater, coating over hot and cold junction and heater.

In my sensor, has a similar substrate (element 61 in my Figure 6) to mount the hot and cold thermocouple junctions (elements 71 to 80 plus element 60 in my Figure 6) , a similar heater (element 62 in my Figure 6) and a thin film (element 64 in my Figure 6) to fulfil the same function as coating.

13) claim 1 in patent # 6,546,796.

" A liquid level sensor comprising :

a substrate having a longitudinal axis;

a first plurality of thermocouples provided on one side of said substrate in longitudinally spaced relationship ;

a second plurality of thermocouples provided on said one side of said substrate in longitudinally spaced relationship to each other , respective ones of said second plurality being positioned in laterally spaced relationship to respective ones of said first plurality of thermocouples ;

said first and second thermocouples being interconnected in alternating series relationship;

a heat source for increasing the temperature of each of said first plurality of thermocouples;

a heat sink positioned in heat transfer relationship to said plurality of second thermocouples ;

said sensor being adapted to be positioned within a vessel containing a volume of liquid with said substrate partially immersed in said liquid such that said first and second plurality of thermocouples will cooperate to generate a signal indicative of the level of liquid within said vessel."

In the apparatus described in this claim, Mr. Zimmermann uses a substrate to mount the hot and cold thermocouples, power source, heat sink and a container for mounting the sensor.

In my patent application, I use a substrate (element 61 in my Figure 6) to mount the hot and cold junctions (elements 71 to 80 plus element 60), a power source (element 52 in my Figure 2) , a common cold junction for all of the hot junction (instead of a Copper heat sink or a heat spreader that will attempt to equalize the temperature of all of the cold junctions) and a container (element 10 in my Figure 1).

14) claim 2 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 1 wherein said second plurality of thermocouples are operative to generate a compensating signal indicative of ambient temperature. "

This will be true only if the temperature of the liquid and gas above it are the same and the cold junctions are not heated.

In contrast, I describe in my patent application on page 38, two lines from the bottom of the page, a more reliable method of determining the ambient temperature of a few points in the liquid and gas. Here is what I wrote in my application " The invention described herein can also be used to determine accurately the liquid or gas temperature at the thermal junctions of the probe. Since the probe responds to the temperature differential between any two thermal junctions along the common strip (Constantan strip in Figure 9), a reference accurate temperature sensor may be located at a convenient point (or the strip extended to such a point) and the temperature at any other point along the probe is resolvable. The calculation of the absolute temperature of each thermocouple

location will be done with software using the thermocouple voltage differential whose non-random errors have been eliminated and random errors have been minimized using filtering which includes averaging and correlation functions. " Note that in my Figure 10, element 97 is the single absolute temperature sensor that will be used to determine the ambient temperature at each hot thermocouple junctions even when the temperature of each hot junction is different than the other.

15) claim 3 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 2 wherein said first plurality of thermocouples generates a signal of a first plurality and said second plurality of thermocouples generate a signal of opposite plurality.

In my patent application, point A in the attached Figure 6 [i.e. single cold junction} will give one sign of the voltage (EMF for the dissimilar metals) and the other connections between the Constantan (element 60 in my Figure 6) and each copper trace (i.e. 71 to 80) will give an opposite sign voltage. The voltage at the junction between element 71 and 60 minus the voltage at point A will give the temperature rise of the junction between element 71 and 60 and the cold junction at A. Similarly, differences voltages are obtained for elements 72 through 80.

16) claim 6 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 1 wherein said sensor includes third and fourth serially connected thermocouples operative to generate a signal indicative of a pressure within said vessel. "

What Mr. Zimmermann is saying in this claim is that if the density of the compressible fluid above the liquid changes due to pressure, then the temperature rise of the heater in the compressible fluid will change. The higher the density of the compressible fluid becomes, the lower the temperature rise of the heater section in the compressible fluid will be. The formula that correlates the pressure to density for compressible fluid is :

$$P = G^* R^*T$$

Where G-is the density of the compressible fluid

R- is a constant

T- is the temperature

If T (environment temperature) is the same but P (pressure) changes then the pressure is directly related to the density of the compressible fluid. When the air becomes more dense, under those conditions only, the temperature rise after power is applied can be used to detect pressure deterioration of the compressible fluid. Furthermore, the design for measuring pressure leakage in this patent will work only if the temperature of the entire compressible fluid is uniform. If the entire compressible fluid above the liquid does not have a

uniform temperature, then this method of determining pressure leakage will not be a reliable method to detect pressure leakage.

On page 38 of my application, about 7 lines from the bottom of the page, I wrote the following :

"The invention described herein can also be used to determine the density of incompressible liquid. By measuring the temperature of the liquid and its pressure (with an appropriate pressure-measuring device such as pressure transducer) at the same location, it is possible to compute, with a suitable microprocessor, the density of the liquid."

For the compressible fluid above the liquid , under special conditions, (i.e. temperature of the compressed fluid above the liquid at higher pressure remains equal to the temperature of the compressed fluid at lower pressure), then by looking at the temperature rise of the hot thermocouple junctions far away from the actual liquid level and averaging them, such a reading can give an indication of the pressure leakage.

17) claim 7 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 6 further comprising a heat source positioned in heating relationship to said thermocouples."

In Figure 6 of my patent application, heater 62 is the heat source and the hot thermocouple junctions (i.e. the junction between Copper trace 71 and the

Constantan 60 in Figure 6). It should be noted that the thermocouples just read the temperature along the heater. The heating of the thermocouples by themselves does not give the temperature profile of Figure 3 in Mr. Zimmerman patent. It is the change in heat that is being generated by the heater as the liquid level rises or fall that in turn heats the hot thermocouple junctions.

18) claim 8 in patent # 6,546,796.

" a liquid level sensor as set forth in claim 1 further comprising a regulated power source for supplying power to said heat source."

In Figure 1 of my application, element 53 is a DC power source and 53 is a switching of the power to the heater. The heater in my patent application and in Mr. Zimmermann patent are heated by a DC source. The switch regulates the power to the heater.

19) claim 10 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 8 wherein said signal from said thermocouples is supplied to signal conditioning circuitry."

In Figure 10 of my patent application, the signal (voltage) from each hot thermocouple junction and the common cold junction is sent through signal conditioning circuit that includes multi-plexers 93 and 94 in Figure 10, differential

amplifier 96 (to accommodate with hardware the positive sign of the hot thermocouple junction and the negative sign of the cold thermocouple junction) , and other components of the signal conditioning circuitry to achieve higher accuracy of the reading that the analog circuitry can not achieve in the presence of normal operating errors such as a non-uniformity of temperature of the liquid and gas.

20) claim 11 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 10 wherein said signal conditioning circuitry includes an amplifier. "

Similarly in my patent application 6 lines from the bottom of page 29, I wrote ". The differential voltage reading for each thermocouple junction will come through differential amplifier 96 whose non-random errors are self-calibrated. "

The function of this amplifier is similar to the amplifier function in Mr. Zimmermann patent.

21) claim 16 in patent # 6,546,796.

" A liquid level sensor as set forth in claim 1 wherein said corresponding ones of said pairs of said first and second plurality of thermocouples are positioned along a line extending generally parallel to the surface of said liquid. "

In Figure 6 of my patent application, the hot (junction between elements 71 to 80 and the Constantan strip element 60 in Figure 6) and cold thermocouple junctions (a single

common cold junction, point A in the attached slightly modified figure 6) for measuring continuous liquid level are positioned generally parallel to the surface of the liquid whose height is being measured.

Conclusion

The Applicant now believes the application to be in condition for examination, and respectfully requests that a timely Notice of Allowance be issued in this case. Should the Examiner have any questions regarding this response or need any additional information, please contact the undersigned at (310) 274-1434.

Respectfully submitted,

J. Maatuk

Date : 1/10/2005

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